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CLOUDS
AND WEATHER PHENOMENA

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CLOUDS
&
WEATHER PHENOMENA

FOR ARTISTS AND
OTHER LOVERS OF NATURE

BY

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INTRODUCTION

A CERTAIN knowledge about clouds, rainbows, halos, mirages and other phenomena of the atmosphere is useful to artists, and may be of interest to many others who, while not wishing to make a deep study of meteorological matters, yet take an interest in the changing pageant of the sky. The usual books on the subject are sometimes too technical, or contain much information on meteorological instruments, the principles of forecasting from weather maps, and other matters, which, though extremely interesting in themselves, are not wanted by those who depict or watch the skies from a less scientific standpoint. It is for these that this book is intended.

The photographs of clouds which appear in the volume were mostly taken with a view of getting as much detail as possible of the cloud structure, and not with a view of making artistic pictures; they are what is known to photographers as contrasty, and are too contrasty for pictures; some of them have been dubbed as too theatrical; in many of them the blue of the sky is almost black; but they are

reproduced here merely to illustrate the various forms of cloud structure. For the information of those who may wish to take cloud photographs it may be mentioned that most of the photographs reproduced here were taken on backed panchromatic plates through a deep yellow or a red screen.

I have tried to make the following pages as non-technical as possible; if any reader finds the first page or two too alarming I would ask him to skip them; he will, I hope, find nothing of an alarming nature further on.

Many artists make a very careful study of anatomy; it seems reasonable that those artists who paint skyscapes should have some knowledge of optical phenomena of the atmosphere and of the scientific principles of cloud classification.

C.J.P.C.

December, 1925

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CLOUDS & WEATHER PHENOMENA

THE COLOUR OF THE SKY

LIGHT consists of waves of the same nature as those used for wireless transmission; the waves used by the British Broadcasting Company's stations are mostly from 300 to 500 metres[1] in length, but the waves which produce the sensation of light are of almost inconceivable minuteness, ranging from 4/10,000 to 7/10,000 of a millimetre in length, a millimetre being the thousandth part of a metre. White light consists of waves of these and all intermediate lengths. With a wireless receiving set we can separate one set of waves from another; with a prism we can separate the light waves; the longer waves, those measuring round about 7/10,000 of a millimetre, are those which produce red light; the shorter, round about 4/10,000 of a millimetre, produce violet light; between these, in order of decreasing wave length, come orange, yellow, green and blue. All these light waves, these different colours, striking the eye at once, produce the sensation of white light.

[1] A metre is rather over 39 inches, and may be thought of as a long yard.

The blue colour of the sky is caused by dust particles which exist in the air, or by the actual molecules of the air. White sunlight passing through the air has the shorter blue waves of light scattered by the dust particles, while the longer waves, particularly those producing yellow and red, are less scattered. There is thus a selection as sunlight passes through the air; the blue light is, so to speak, filtered out and scattered in all directions, and consequently blue light reaches us from all parts of the sky. When the sun is low in the sky its rays have to pass through a great thickness of air before they reach our eyes and nearly all the blue rays have been filtered out; but the yellow and red rays reach us, and the setting sun appears red. The smaller the particles to which the scattering is due, the purer will be the blue colour, and as we go up a mountain or in an aeroplane, and get away from the more dusty layers, the blue colour deepens. When there are a great number of dust particles in the air the blue becomes rather pale; after rain when the dust particles have been washed out of the air, the blue becomes more intense. The blue of the sky is less intense near the horizon because the light from these parts has had to pass through a greater thickness of the lower

atmosphere, where dust is more prevalent. Soapy water, which contains a number of fine soap particles, looks red when we look through it and blue when light falls on it and when we look at it from the side; the reason is precisely the same as that which causes the blue of the sky; the light has the blue rays scattered, while the red and yellow pass through.

SUNSET COLOURS

It has already been explained why the sun looks red when near the horizon. Clouds turn pink or red at or after sunset because the sunlight which still reaches them has passed through a great thickness of the atmosphere, and has had all its blue rays filtered out and scattered, and only the red and yellow rays reach the clouds. But besides the ordinary sunset tints on the clouds there are a succession of appearances that may be seen when the sun sets in a clear sky. They may be classified as follows:

A. The First Twilight

1. The First Counterglow. The pink colour just before and a little after sunset, which is seen in the eastern sky, is caused by sunlight reflected from particles in the atmosphere after it has had its blue light filtered out as explained above.

2. The First Earth Shadow. The sky near the eastern horizon shows a dark band below the counterglow when the sun has set; as the sun sinks lower below the horizon this band rises higher, and is seen to be arched; this is merely the shadow of the earth on the atmosphere.

3. The First Twilight Glow. This is first seen in the west as a whitish patch over the sun a little before sunset; after sunset it becomes more evident, and as the sun goes down it spreads out along the horizon, forming a bright band between the blue sky and the yellow horizon.

4. The First Twilight Arch is the upper edge of the first twilight glow.

5. The First Purple Light appears after the sun has set; it is a diffused purple patch, semicircular in shape, and fading off at its edges till it merges imperceptibly into the blue of the sky.

These phenomena can be explained by sunlight shining on the upper parts of the atmosphere after the sun has set on the ground level.

B. The Second Twilight

All the above effects appear a second time, the second appearances being due not to

actual sunlight but to the sunset glow in the far west shining on the upper atmosphere, as did the sun itself during the first twilight. The second twilight effects are mostly very faint, and some of them can hardly be seen in our country except on very favourable occasions, and even then they would have to be watched for closely. In any case they are only visible when the sky is very clear.

Weather modifies the sunset very much, and sometimes, instead of the yellow or reddish twilight glow, the western sky assumes a greenish hue; this may be due to much water vapour in the atmosphere; it does not occur in dry fine weather.

SUNSET RAYS

We often see rays of light radiating from the sunset; they occasionally extend to the zenith, and more rarely actually right across the sky to the eastern horizon. They are of the same nature as the rays of sunlight seen when the sun is shining through gaps in clouds, the phenomenon popularly known as the sun "drawing up water." When mountains or cloud heads lie on our horizon at sunset they will cast shadows across the dust-laden air above us; the parts of the sky in the

shadows will appear dark, the other parts light. If the clouds or mountains are extensive most of the sky may be in shadow, and the remaining parts look like beams of light radiating from the horizon; they are of course parallel, and only appear to radiate from the effect of perspective. If there are only a few clouds or mountains most of the sky will be bright with dark bands radiating from the horizon. The writer once saw, when in the north-west of Hampshire, such a dark band extending right across the sky; it was the shadow of a cloud which was over Plynlimmon in Wales.

RAINBOWS

The ordinary rainbow is sufficiently familiar, but one not infrequently finds mistakes concerning it, the most obvious one being a reversal of the colours. There are normally two rainbows to be seen, an inner bright one and an outer faint one. The rule about the colours is that the two reds come together, that is, the inner rainbow has the red on the outside edge, and the outer bow has the red on the inside edge. The colours are of course the ordinary colours of the spectrum, though the violet end is not usually seen. Inside the

primary bow and more rarely outside the secondary bow may sometimes be seen what are known as supernumerary bows, one or more according to circumstances. The colours of these are not so pure as those of the rainbow proper; those most usually apparent being pink or rose, and green. The supernumerary bows often change rapidly, fading away and appearing again at intervals. Though a typical rainbow consists of all the colours of the spectrum it often happens that some of the colours are missing, commencing from the violet end; when for instance the sun is low down and shining through a misty atmosphere, so that all the blue light has been cut out of the sun's rays, blue cannot appear in the rainbow. When the sun shines on a very fine drizzle, which very rarely happens, or when, as happens rather more frequently, it shines on a bank of fog, a nearly white bow is seen; this is usually called a mist-bow.

It should be noticed that the sky inside the primary bow is distinctly lighter than that outside.

The position of a rainbow is of course opposite to the sun, and the top of the arch is directly opposite the sun's direction. The centre of the circle of the bow is the point directly opposite the sun's position, so that in

general the bow is less than a semicircle; if, however, the sun is on the horizon the bow is a semicircle, but this does not often happen. The higher the sun in the heaven the smaller will be the segment of the bow that is visible, and in summer in England the sun is so high that, in the middle of the day, no part of the rainbow can be seen against the sky, but sometimes, when the sun is high and there is rain close at hand, and very bright sunshine, a small segment of the bow may be seen projected against the background of trees or hills; this would be specially noticeable if the observer, standing on a hill, were looking down on to a valley where rain was falling.

It may be useful to give the actual angular dimensions of a rainbow. From the centre of the circle, that is, from the point directly opposite to the sun, which point will in general be below the level of the horizon line, it is 41 degrees to the middle of the primary bow, and 53 degrees to the outer or secondary bow.

A lunar rainbow is very rarely seen; it can only be seen when the moon is getting on to full and therefore the number of nights on which it can be seen is limited, and heavy showers with patches of clear sky between, the conditions necessary for a rainbow, are much rarer at night than during the day.

Owing to the faintness of moonlight compared to sunlight, the colours are not usually seen, just as the colours of flowers are not usually seen by moonlight; a lunar rainbow therefore is practically white. Naturally the position of the lunar rainbow with regard to the moon follows the same laws as those of the ordinary rainbow with regard to the sun.

Occasionally portions of rainbows are seen which are not in the normal positions; for instance an arc of a bow is sometimes seen extending upwards and outwards from the base of an ordinary rainbow. This is probably caused by the reflection of the light of the sun on still water. These abnormal bows are so rare however that an artist is hardly likely to include them in a landscape, or perhaps one should say a seascape, for they are only seen near the sea or some large lake.

HALOS

Besides rainbows there are other coloured rings that are of a different nature; these are called halos and are seen round the sun or moon. The halo most commonly seen is 22 degrees from the sun or moon; it is usually a whitish ring but sometimes colours are visible; in this case the red is on the inside of the circle followed by yellow and green; when

seen round the moon the colours are hardly ever visible. A halo is an optical phenomenon caused by the sun shining through clouds composed of minute ice crystals, but sometimes these clouds are so thin that the only indication of their presence is the fact that a halo is visible; it is on these occasions that the colours are best developed. An outer halo 46 degrees from the sun or moon is sometimes seen. A circle through the sun, called the horizontal halo, may be seen at times; this is white and lies parallel to the horizon; it is sometimes called the mock sun ring for on it are situated the mock suns, or parhelia; the two most generally seen occur close to the place where the mock sun ring cuts the 22 degree halo; they are just outside the halo, and the higher the sun in the sky the further off are they from the halo; they are sometimes white but generally show prismatic colours with the red nearest the sun; they are more or less drawn out on the side away from the sun; they may be seen on many occasions when no halo is visible; sailors call them sun dogs, and they are popularly supposed to be a sign of bad weather. Sometimes small arcs of circles may be seen touching the halos above and below the sun. There are a very great variety of optical phenomena connected with halos, but they

are mostly very rare. Fairly frequently a sun pillar may be seen extending vertically upwards from the sun at about the time of sunset; this is usually white, but it may be reddish, especially just after sunset. This appearance is also caused by minute ice crystals in the upper air; the sunlight is reflected from their faces, and the phenomenon is somewhat analogous to the band of light, or "wake," seen in the sea or other sheet of water under the sun and moon.

CORONAE

These are coloured rings round the sun and moon but they are quite different from halos; they are formed when the sun or moon is shining through light clouds, and they are quite close up to the sun or moon; the colours are in the reverse order to the halo, the red being on the outside; sometimes the colours are repeated one or more times, in all cases the red being the outer colour of each circle. Coronae are caused by the sun or moon shining through the fine water drops of which the cloud is composed. Since halos are formed by clouds composed of ice crystals, and coronae by those formed of water drops we do not get the two together as a general rule; but it occasionally happens that a halo and a

corona are seen at one and the same time. This may happen when there are two layers of cloud, one composed of ice crystals, the other of water drops, both being sufficiently thin for the sun or moon to shine through them. Coronae are often not noticed round the sun as they are lost in the glare of the sunlight; they may very often be seen with the aid of dark glasses, or reflected in pools of water, when they cannot be easily seen by direct vision.

BROCKEN SPECTRES

These are apparently huge shadows seen on mist. They were observed on the Brocken in Germany, hence their name, but they may be seen under suitable conditions in any hilly country. The author has seen one from the Portsmouth road about two miles south of Butser hill. About a couple of hundred yards away the ground fell away into a valley that was filled with a slight mist; beyond the ground rose again at a distance of between a quarter and half a mile; the observer's shadow was projected on the mist about 200 yards away, but it looked as though it were on the opposite hill nearly half a mile away. To the mind's eye the shadow appeared nearly half a mile away, but since it was really much nearer it appeared to be inordinately large.

IRIDESCENT CLOUDS

Sometimes light clouds of the higher varieties are seen to have colours developed on them; red and green are the most prominent; they are seen in clouds near to the sun, but there is no definite distance from the sun at which they are seen, and the colours are arranged in an irregular manner; they are not nearly so rare as might be supposed, but they are often missed, as are halos and coronae, owing to the glare of the sun; halos, coronae and iridescent clouds may be seen best with the help of dark glasses, or by their reflections in pools of still water.

MIRAGES

A mirage is a subject about which there is a good deal of misconception. A flat surface, when heated by the sun, heats in its turn the layer of air in contact with it. When a ray of light falls on a heated layer of air at a glancing angle it is bent upward again as though reflected. If an observer stands at *A* (Fig. 1) and looks at a point *R* on, say, a heated road surface, he will see objects which may lie on the line *RS*; if there are no solid objects on this line he will see the sky at *S* apparently reflected at *R*, and the road surface at *R* will appear as though it were covered with water. If the observer goes nearer to *R*, say to the

point *B*, he will no longer see the mirage at *R* because no ray of light falling on the road surface at *R* can be bent up sufficiently; it is only glancing rays that are bent up and they are not bent up except at very small angles. If, however, the observer at *B* stoops down so that his head is in the position *C* he will see the mirage again as though he were at *A*. I am informed by someone who motored in the desert that he once saw a mirage in every direction so that he seemed in an island sur-

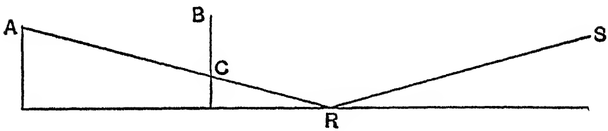

Fig. 1

rounded by a sea; but his island moved with him; he naturally could not see a mirage close to him for the reason explained above. The popular novelist who described a desert scene when the mirage was so close that the rider saw his camel nearly putting its foot into it was describing an impossible phenomenon.

Mirages are not only seen in the desert; in the summer they may be seen on roads in England, especially on tarred roads which become intensely heated by the sun. The best place to see them is just before one comes to

the top of a rise, when the observer's eye looks along a level stretch ahead; quite a good one is to be seen in this way on the approach to Waterloo Station. The subject was taken up by the popular press in the hot summer of 1921, but mirages may be seen in any tarred road on any bright summer day.

CLOUDS

Clouds have presented difficulties to many artists, and one frequently sees a landscape entirely spoilt by having impossible clouds. Some artists who are aware of the pitfalls that lie in wait for them, when dealing with skies, try to avoid the difficulty by making fluffy cotton wool-looking marks do duty for clouds. Artists are not alone in this attempt to get over a difficulty by illegitimate methods. The photographers who use the bromoil, or other process in which there is considerable "control," too often make a sky effect by dabbing off part of the pigment on the sky and making the clearer parts so produced do duty for clouds. No doubt clouds are difficult to paint; they change with extraordinary rapidity, not only from their motion, but in their lighting and in their actual form. A sunset sky with clouds will change in its lighting from minute to minute, and it is often im-

possible to sit down and paint a sky from nature; much must be left to the memory. But the artist who studies cloud forms can and does paint skyscapes which are truthful representations of what is really seen. A visit to any picture gallery shows not only some skies that could never have existed, but also many which can be recognised by the most exacting meteorologist as typical skyscapes. But pitfalls do exist, and even in the works of the great masters one may see impossible compositions.

A knowledge of cloud forms is really quite easily gained by anyone who is observant, and a study of the sky itself is a far better lesson than any amount of reading; but nevertheless some familiarity with cloud classification is a great help.

Perhaps the first thing to be learnt is that clouds may be divided into two groups, sheet clouds and heap clouds. The sheet clouds are arranged in horizontal layers of no great vertical thickness as a rule. They may form extensive sheets covering the whole sky (Fig. 2) or the sheet may be reduced to a few detached clouds (Fig. 3) which however are all floating at some definite height above the earth; a layer exists at this level at which, owing to conditions of temperature and moisture, condensation is

nearly taking place, and in some places condensation actually does take place, with the formation of a cloud. There may be several layers of cloud at different heights, the upper seen through gaps in the lower layer (Fig. 3). The thing to remember is that these kinds of clouds extend in a horizontal sheet, broken up it may be, and sometimes extend away to the horizon; the rules of perspective must be followed accordingly. This is well seen in the long lines of cloud which may sometimes extend across the whole sky in parallel lines, the effect of perspective making them appear to radiate from a vanishing point on the horizon (Figs. 4, 5).

It will perhaps be a good thing to give a short summary of the classification of cloud forms, as a knowledge of such classification cannot fail to be of use to the artist who includes clouds in a landscape.

I. Clouds in horizontal sheets, sometimes covering the whole sky, sometimes more or less broken up, and sometimes reduced to a few isolated patches.

1. *Cirrus:* clouds composed of threads or fibres (Fig. 6), sometimes in isolated wisps or tufts (Fig. 7), sometimes in compact masses (Fig. 8), or, it may be, arranged in long lines across the sky (Fig. 9), or in waves (Fig. 10).

Very often the streaks of cirrus have their ends turned up into little tufts (Figs. 11, 12), more rarely the tuft becomes the principal part of the cloud, giving rise to the form known as tailed cirrus (Fig. 13). On the advancing edge of a sheet of cirrus there may be plume-shaped clouds (Fig. 14). Cirrus may cover the whole sky, sometimes in detached masses (Fig. 15), sometimes making a continuous sheet. In the latter case it is known as cirro-stratus, and may be made up of tangled fibres or threads, or it may be a structureless sheet giving a white milky look to a part or the whole of the sky (Fig. 16). Sometimes the sheet may be so thin as to be invisible, and is only recognisable by the halos that accompany it. (See under "Halos.")

These clouds, cirrus and cirro-stratus, are made up of minute ice crystals in the higher part of the atmosphere; practically all other clouds are composed of minute drops of water. Cirrus clouds are usually at a height of 20,000 to 30,000 feet, and may be seen floating above the tops of high mountains; they often move from a different direction to the surface wind and the lower clouds, as they may be in a different wind current. They tend to move outwards from areas where the barometer is low, and when seen moving

from the west or north-west with a southerly (south-east to south-west) surface wind it is usually a sign of bad weather advancing from the west. The frayed-out fibres (Figs. 6, 9, 12, 15) are popularly supposed to mean wind, and a windy sky in popular language is often synonymous with some varieties of cirrus cloud; but the connection is not a real one; we often see frayed-out streaks of cirrus in very quiet weather.

2. *Cirro-cumulus* consists of cloud masses composed of smaller cloudlets which do not show fibrous or thread-like structure; in typical cases the cloudlets have a round outline, but many varieties exist, and in some cases the cloudlets of cirro-cumulus are intermingled with cirrus threads. The cloudlets may be very minute (Fig. 17), or they may be larger and more definite (Fig. 18); they are generally arranged in some sort of order, that is, in bands or waves, very often the wave structure is well marked; it may be very beautiful, giving rise to the so-called mackerel clouds (Figs. 19, 20). A mass of cirro-cumulus is often thicker in the middle than at the edges, and in these cases the edges are often rippled; the whole cloud is then lens-shaped and is known as lenticular cirro-cumulus (Fig. 21); the rippled edges if closely watched

are seen to change continually, and very often the cloud may be seen to grow on the windward side and to dissolve on the leeward side, so that the whole cloud may remain nearly stationary while the actual cloud particles are moving. These lenticular clouds are curiously inconstant and grow, change, and dissolve in a remarkably short time. The long bands of cirro-cumulus which sometimes trail across the sky, especially in this country with a north-west wind, often break up into wave forms (Fig. 22). Cirro-cumulus certainly gives us the most beautiful skyscapes; it is seen both before and after bad weather, but its most beautiful developments are after hot summer weather when thundery conditions are approaching from the west. The delicate rippled structure and the fine masses of delicate cloudlets (called *petits moutons* by the French), and the pure white colour are distinctive; the cloudlets rarely have any shadows on them. At and after sunset they take up the pink and rosy tints of the sunset sky. These clouds are usually at heights of 20,000 to 25,000 feet. Curious forms of cirro-cumulus are sometimes seen over high mountains, their shapes being probably due to eddies formed by the wind blowing over the mountain masses (Fig. 23).

3. *Alto-cumulus*. There is not much to distinguish these clouds from cirro-cumulus, except that the size of the cloudlets is greater, and being also thicker they do not show such a pure white colour, and have some shadows on them (Figs. 2, 24). We see the same arrangements of cloudlets in bands and waves (Figs. 2, 25, 26), but the waves are coarser, and one does not see the very fine rippled structure. The coarser cloudlets are called *gros moutons* by the French to distinguish them from the *petits moutons* of the cirro-cumulus. It is probable that height really distinguishes the two varieties of cloud, and that in essentials there is little difference between them. One frequently sees clouds that even a trained meteorologist would have a difficulty in putting into one class or the other. The height of alto-cumulus ranges round about 15,000 feet. There is one curious variety of alto-cumulus called turret cloud, in which the individual cloudlets are drawn up vertically into miniature cumulus (see p. 24) with white gleaming tops, rising from rather flat masses (Fig. 27); this type of cloud is an almost sure precursor of thundery conditions.

Just as a structureless sheet of cloud may be seen at the cirrus level (cirro-stratus) so the same formation may be found at the level of

alto-cumulus, especially just before rainy conditions spread over the country from the west (Fig. 28). Alto-stratus is thicker than cirro-stratus, the sun shines through it with a "watery" look, but there are no halos or mock suns to be seen in the lower form of cloud.

4. *Strato-cumulus*. This is the lowest form of sheet cloud, and may be found at any level from a couple of thousand feet or less up to about 10,000 feet. Just as alto-cumulus merges into cirro-cumulus, so strato-cumulus merges into alto-cumulus. Strato-cumulus has a still coarser structure; it is sometimes in isolated patches (Fig. 29), but more often it covers the whole sky (Fig. 30). It is sometimes in rolls or waves with patches of blue sky showing between the waves. In quiet weather in winter it often covers the whole sky with a persistent cloud canopy, which at times may be very thin so that patches of blue sky are visible (Fig. 31). In summer strato-cumulus has a tendency to break up and to become cumulus.

5. *Stratus*. This cloud has sometimes been described as a fog which is not in contact with the ground. It is frequently seen in detached patches (Fig. 32) which are often lenticular in shape. Stratus may form over and among hills

and mountains, and patches of stratus may often be seen on the margins of large thunder-clouds, appearing dark against the white cumulus.

6. *Fog* is a cloud which is in contact with the ground. The general cloud sheet may be lower than the tops of the hills, and in such a case a fog is experienced on the hills, but this can hardly be classed as a true fog. During a cold and nearly still night chilled air runs down the sides of hills and fills the valleys with cold air which may be so cold that its water vapour is condensed into a fog. Such fogs are seen beginning to form over damp meadows or marshy ground at about sunset on some clear still evenings; by the early morning such fogs may fill a whole valley (Figs. 33, 34). On summer mornings they soon disperse, but in the winter they may last well into the day, and sometimes they may not clear away all day. When a valley runs down to the sea a valley fog may be seen flowing out to sea for a considerable distance in the early mornings; such fogs may be seen on the Devon coast, and elsewhere where narrow valleys run right down to the sea coast.

II. Heap clouds are clouds with a considerable vertical thickness, usually with rounded tops and flat bases. The smaller

kinds are called simple cumulus, the larger ones, that cause showers and thunderstorms, are called cumulo-nimbus. Simple cumulus is sometimes rather difficult to distinguish from strato-cumulus, especially when strato-cumulus is breaking up into cumulus, as often happens on summer mornings. Sometimes the sky may be covered with masses of cumulus of small vertical thickness (Fig. 35) or they may be more scattered, sometimes with a tendency to be arranged in parallel bands (Fig. 36), sometimes scattered irregularly over the sky (Fig. 37). A cumulus cloud of any size has a flat base, and when many cumulus clouds are seen at the same time they will all have their bases at approximately the same height, an important point when drawing clouds. Such small cumulus clouds may form and never develop into large clouds, in fact on most fine summer days such clouds form during the morning and disappear again in the evening. Under certain circumstances, however, they grow to larger proportions (Figs. 38, 39) and sometimes rise to towering heights (Fig. 40).

After a certain stage of growth a curious change is seen to occur at the top of a large cumulus; the hard rounded head begins to get soft and to fray out into a fibrous mass resembling some forms of cirrus and hence

named false cirrus (Fig. 41) and the whole cloud is now known as a cumulo-nimbus. Rain may fall from any large cumulus but it is only when the false cirrus is developed that the heaviest showers and thunderstorms occur. In heavy thunderstorms there may be a great development of false cirrus (Fig. 42) and the whole top of the cloud may lose its cumulus shape (Fig. 43) and frequently the false cirrus spreads out and gives the cloud top an anvil shape (Fig. 44). Cumulus may occur at many heights; the tops of large clouds may be at 20,000 feet or more, and distant thunderstorms may be recognised by the cloud tops seen at great distances; the writer has seen such cloud tops 160 miles away. Cumulus when opposite to the sun is gleaming white; when at right angles to the sun deep shadows are seen where rifts and valleys occur between the mountain-like peaks; when seen against the sun they are dark (Fig. 45), and have a "silver lining" when the sun is directly behind the cloud (Fig. 46).

III. The remaining cloud form which we have not yet considered is the grey formless cloud of the wet day known as nimbus or rain cloud. It is formless and grey as seen from below; above it there are almost always other cloud forms, particularly alto-stratus; indeed

it is probably from the latter that most of the rain falls, not from the rugged nimbus below it.

THE MOON

Though not connected with meteorology it may perhaps be useful in this place to mention a few facts about the moon, as mistakes are often made when the moon is included in a landscape.

Since the light of the moon is merely reflected sunlight it follows that the convex side of the crescent or of the half moon is always directed towards the sun's position. The direction in which the half moon is seen must be at right angles to the sun's position whether the sun is above the horizon or below it; the crescent moon must be nearer the sun than a right angle; the smaller the crescent of the moon the nearer it is to the sun and therefore a very thin crescent must not be depicted a long way from the sunrise or sunset; the new crescent moon is near the position where the sun has set, the old "decrescent" moon is near the place where the sun will shortly rise. A full moon rises in the east at the time the sun is setting in the west, it is south and high in the sky at midnight, and it sets at sunrise.

A gibbous moon, that is, a moon that is between half and full, rises before sunset when the moon is waxing, and after sunset when the moon is past full or waning. A gibbous moon has its sharp convex edge directed to the sun's position, therefore it has its sharp edge turned to the west before, and to the east after full moon. This point is not always noticed, and the author has seen a picture whose title indicated that evening was in question, with the gibbous moon rising and its sharp edge turned to the eastern horizon, an impossible position.

The position of the crescent moon calls for further note. In the spring the crescent moon is nearly above the sunset, though a little to the left, and the crescent is "on its back." This is a purely astronomical condition and has nothing to do with the weather; the March crescent moon is always on its back. As the year advances the crescent moon moves, at each new moon, further to the south, or to the left of the sunset, and is lower down on the horizon; by the autumn the new crescent moon is low down to the left of the sunset, and is very nearly upright; as the season advances further the crescent, at each new moon, gradually moves back till it reaches its March position again. Under no circumstances can the crescent moon be seen to the

north or right-hand side of the sunset in our latitudes. In the southern hemisphere however things are reversed; the crescent moon will be on the north or right of the sunset position; the March crescent will be low down to the north of the sunset, the September crescent will be high over it.

At sunrise the old decrescent moon will, in the northern hemisphere, be low down to the south or right of the sunrise in the spring, and will be nearly upright; in autumn it will be high up over the sunrise, and on its back in middle northern latitudes. In the southern hemisphere things will be reversed as with the new crescent. In the tropics the new crescent and the old decrescent will be seen on its back over the sunset and sunrise respectively all through the year.

The full moon is high up in the heavens at midnight in the winter, and low down in the summer; in both cases it is towards the south. It is a rough rule that the full moon travels across the sky in nearly the same path that the sun took six months before.

THE APPARENT SIZE OF THE SUN AND MOON ON THE HORIZON

The sun and moon, and for the matter of that the constellations also, appear to be much larger when near the horizon than they do when high up in the sky. The effect is not a real one; it is perhaps due to our estimation of the shape of the sky. We do not estimate this as a hemisphere but as a shallow inverted bowl; consequently we imagine the sky at the zenith to be nearer than that at the horizon. The sun and moon have the same angular diameters whether they are high up or low down, but they appear larger when on the horizon because we are imagining them to be further away; if you see a man one hundred yards away, but for some reason or other estimate his distance as two hundred yards, he will appear to be a giant. The whole effect is purely subjective.

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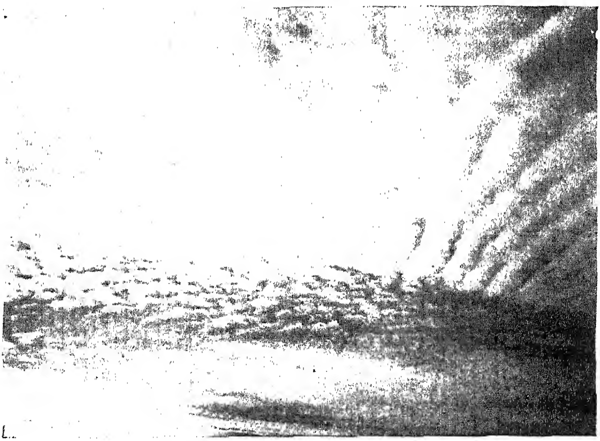

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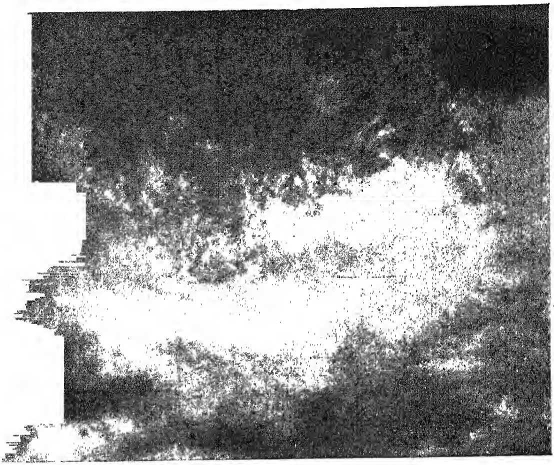

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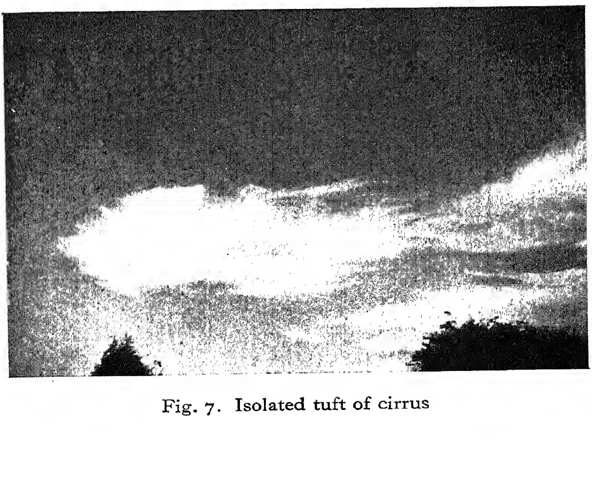

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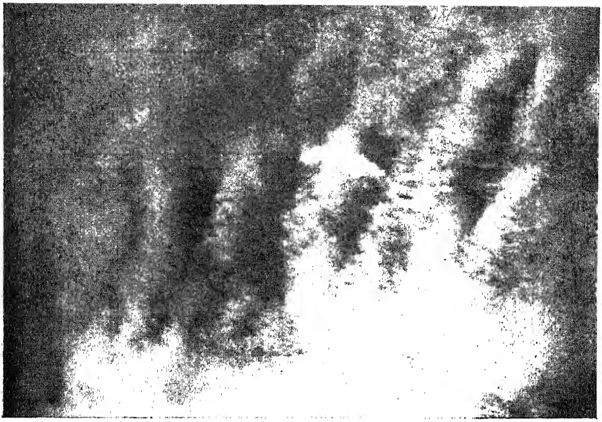

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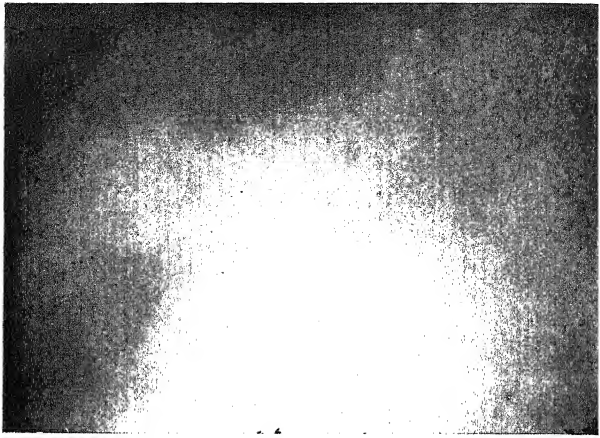

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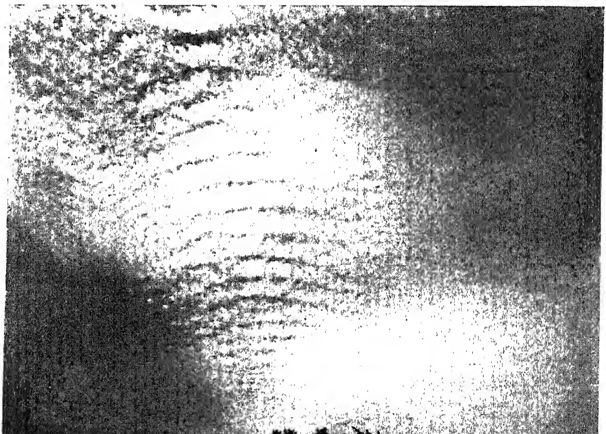

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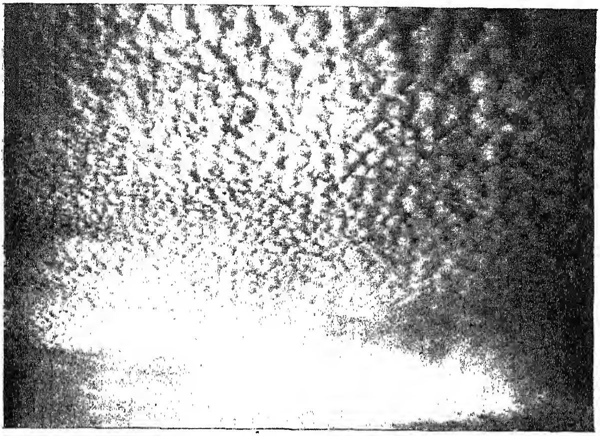

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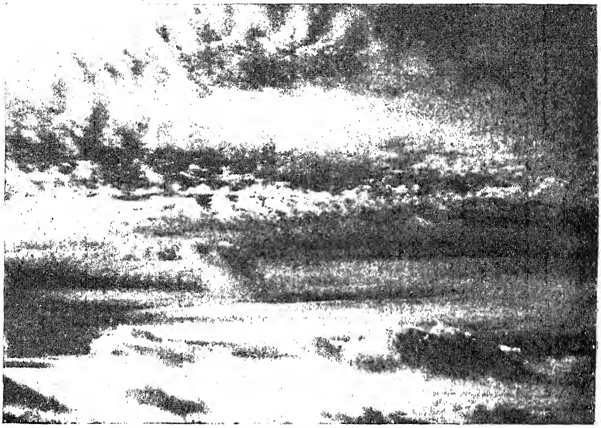

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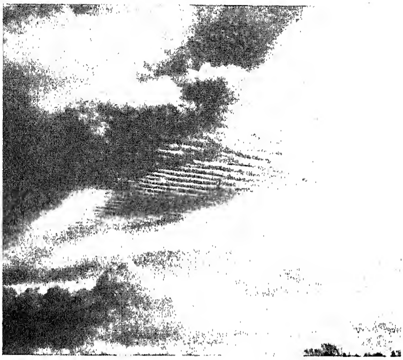

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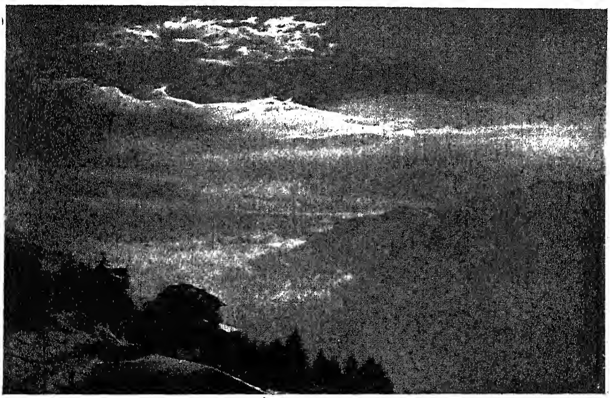

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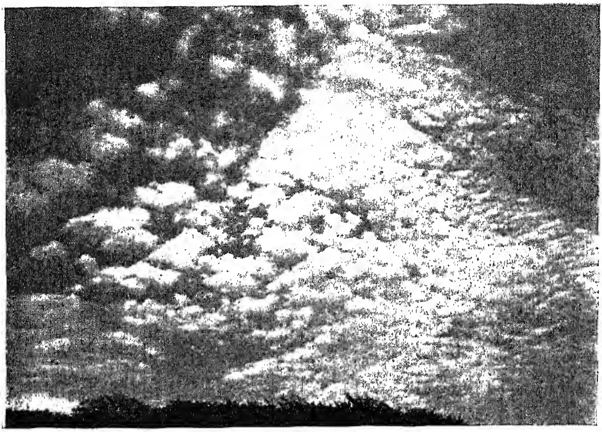

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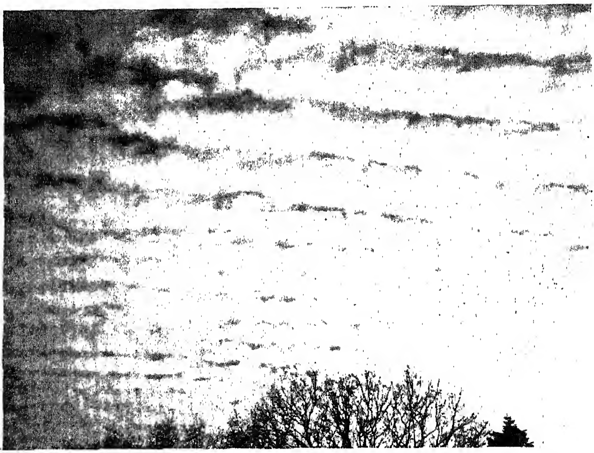

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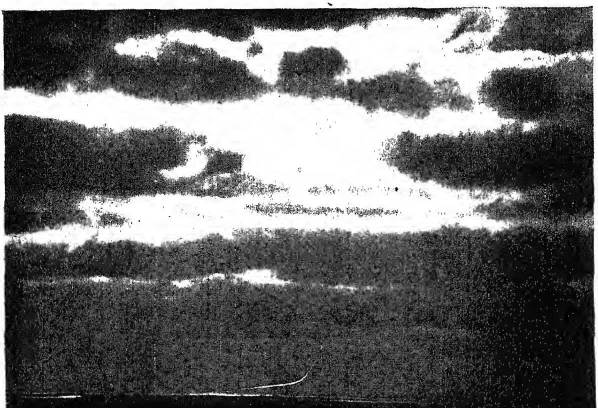

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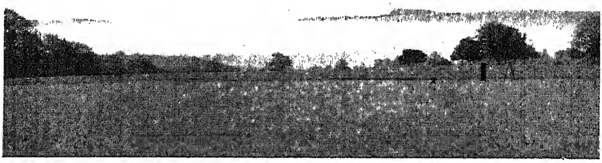

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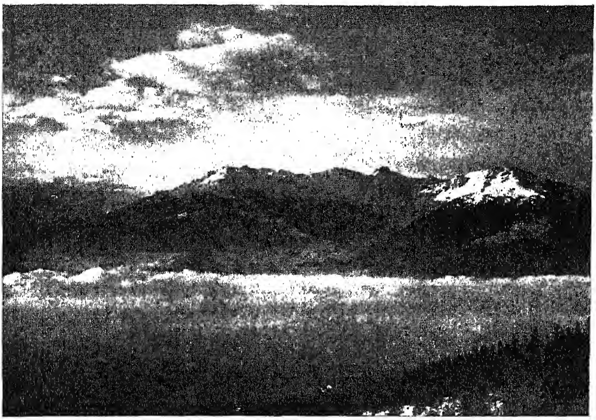

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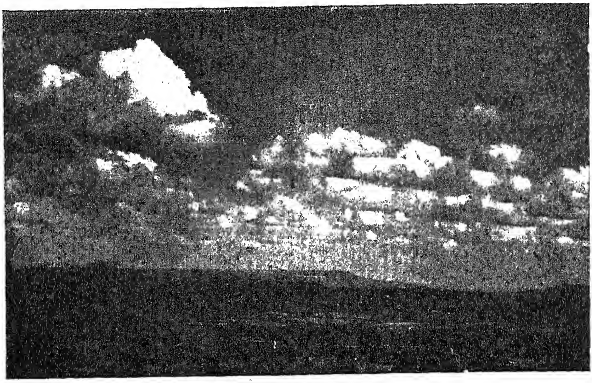

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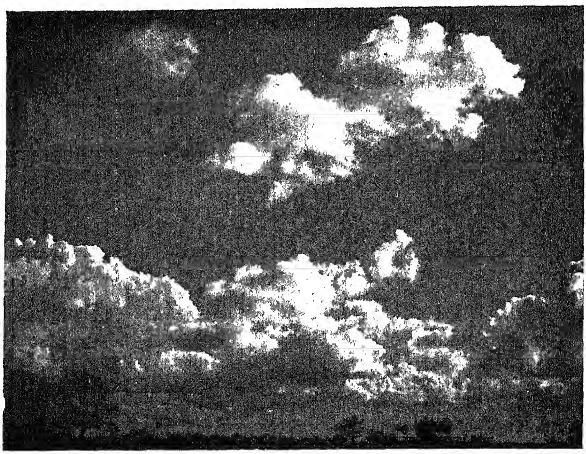

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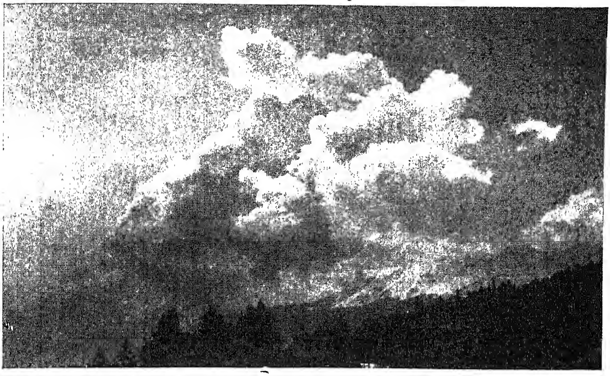

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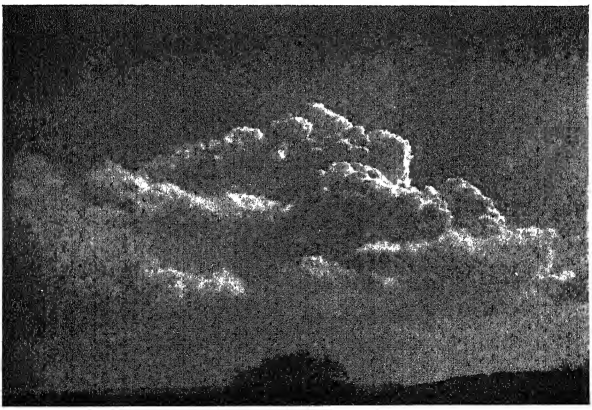

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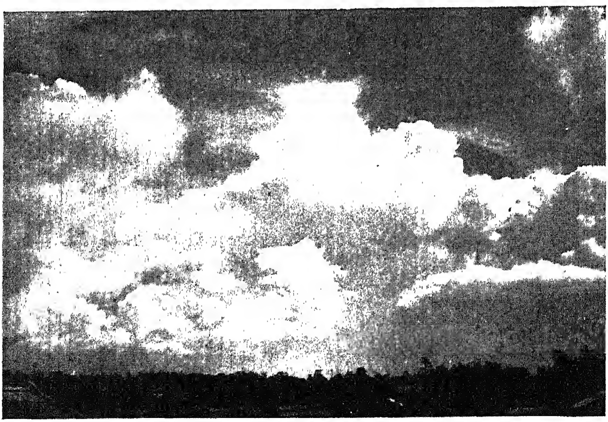

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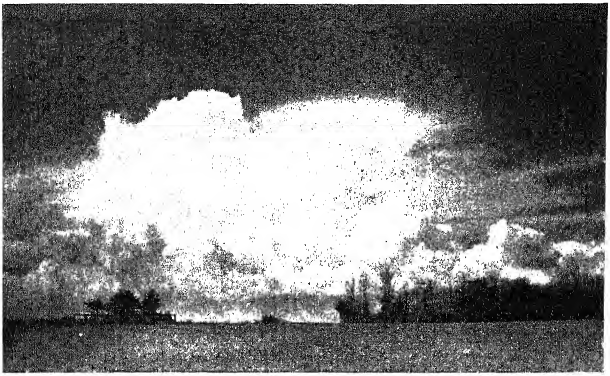

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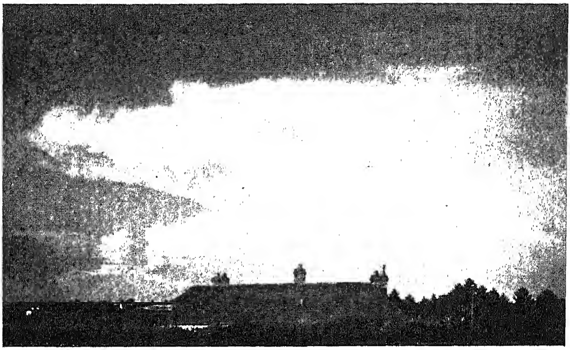

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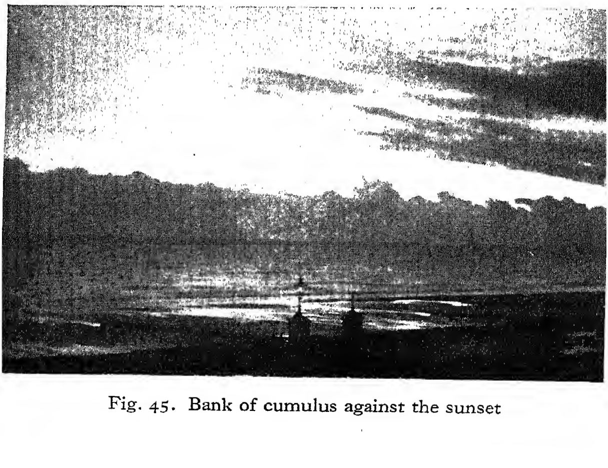

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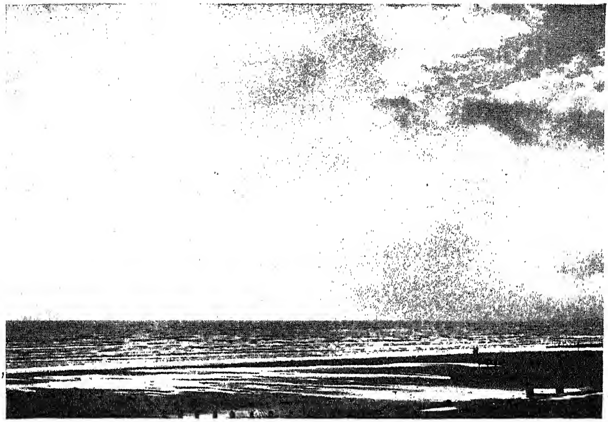

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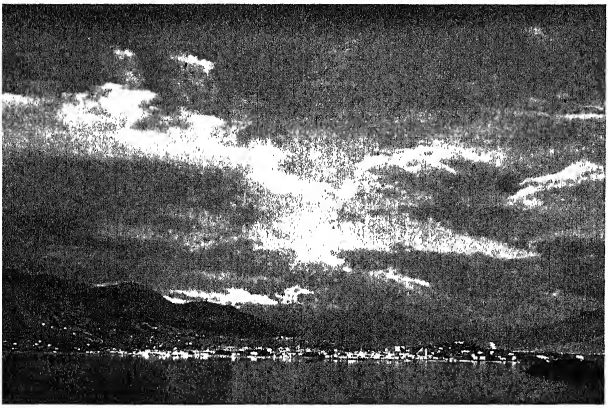

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